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PROJECT REPORT

SUNFLOWER PLANT POPULATION IN CENTRAL QUEENSLAND

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ABSTRACT

Plant populations and their influence on yield in sunflower have been the subject of considerable discussion among farmers and extension and research workers in recent years.

In this report, research, extension and farmer information and data are reviewed. The author reports on a trial he conducted to investigate the subject.

The results suggest that plant populations in raingrown sunflower crops should not be less than 30,000 plants ha^{-1}. If yield expectations can be predicted, populations can be adjusted.

Implications for extension and research are also discussed.

INTRODUCTION

An adequate plant population is essential for optimum sunflower yields. In recent years there has been much discussion among farmers, extension workers and researchers on the subject of sunflower plant populations, particularly for the Central Queensland region.

This report reviews research, extension and grower information on sunflower populations, with attention to Central Queensland. A research trial by the author is reported. Other factors that influence plant population recommendations in Central Queensland, such as the interaction between plant population, row spacing, plant uniformity and variety are discussed.

The problem of achieving a target plant population in Central Queensland and the need for improved planting technology to enable better use of information on plant population, are also discussed.

1. RESEARCH INFORMATION

(a) Effect of Plant Population

Research conducted on the Darling Downs by Radford (1978) found that plant populations in the range of 40,000 to 60,000 plants ha^{-1} were optimum for rain-grown sunflower yields.

Radford (1981) stated that growers should aim for populations no lower than 35,000 ha^{-1}, based on trial results from the Darling Downs and Roma Region. Populations less than 35,000 plants ha^{-1} would give a good yield in dry seasons but because a yield "plateau" occurred, so would much higher populations.

Donald (1963) depicts the theoretical family of curves for "good", "average" and "poor" seasons shown in Figure 1 below. Under good seasonal conditions higher plant populations are optimal for yield than in less favourable seasonal conditions.

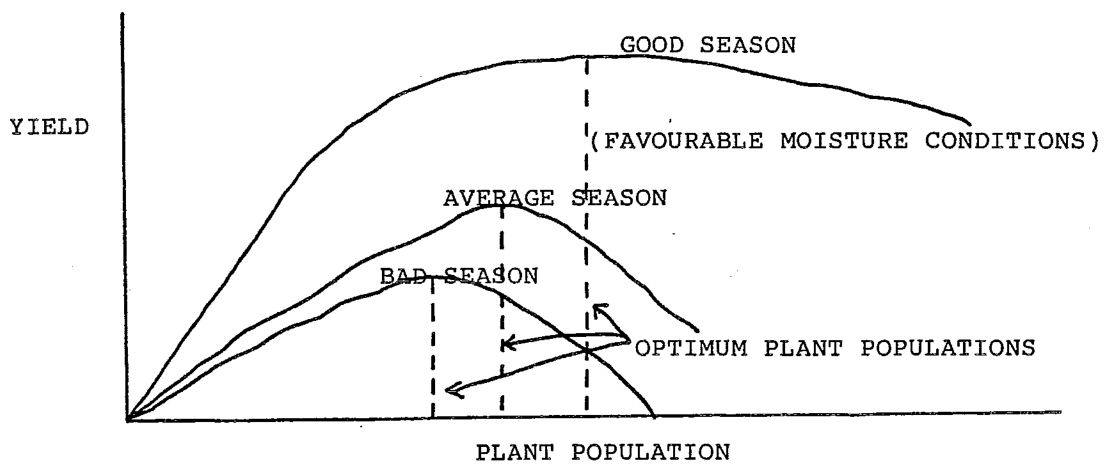


FIGURE 1. The effect of Plant Population on Yield Under Different Seasonal Conditions.

Radford stated that there were other agronomic advantages of higher populations:

* less yield loss due to uneven plant distribution along the row.

* less yield loss due to low establishment percentages.

* smaller seed is produced which has a higher oil percentage.

* smaller heads are produced which dry out more quickly before harvest, reducing bird and weather damage.

* better ground cover in the early growth stages, which gives better weed control and better protection from soil erosion.

The work of Radford was used as a "yardstick" for plant population recommendations in Central Queensland.

The first plant population experiments in Central Queensland were conducted by Foreman (1981) in 1980 at nine locations. An early-maturing variety (Hysun 10) and a later-maturing variety (Hysun 30) were planted at 10, 30, 50, 70, 90, and 110 thousand plants per hectare. Yields varied considerably. The optimum plant population at the high-yielding locations was 30,000 to 110,000 plants per hectare, and at the low-yielding locations 10,000 to 50,000 plants per hectare.

Because rainfall variability in Central Queensland is high and yields could be high or low, the optimum population to cover all situations lies in the area of overlap of these two lines, i.e. 30,000 to 50,000 plants per hectare. (See Figure 2 and Figure 3). Seed size decreased and oil content increased at the higher plant populations. It was concluded that plant populations should not be below 30,000 plants ha^{-1}, and where higher yield goals were likely or growing conditions were good, the optimal population could be increased to 50,000 plants ha^{-1}.

<u>FIGURE 2</u>. Effect of Plant Population on Yield in Sunflower in 1980 trials in Central Queensland.

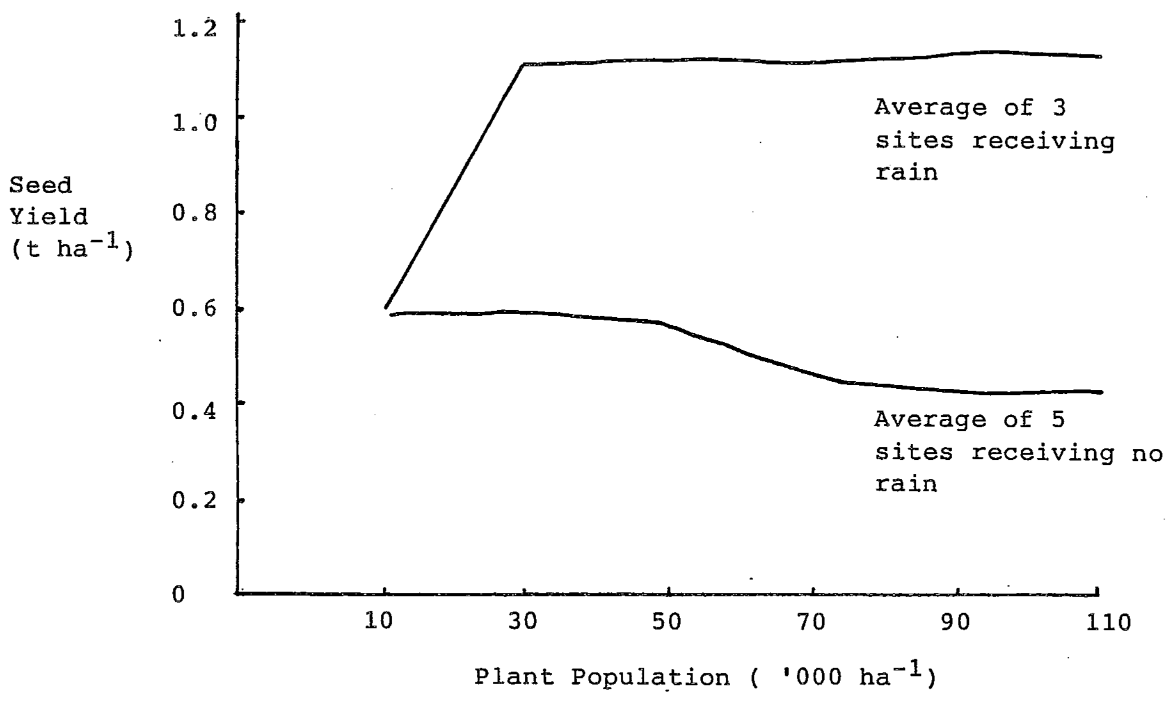
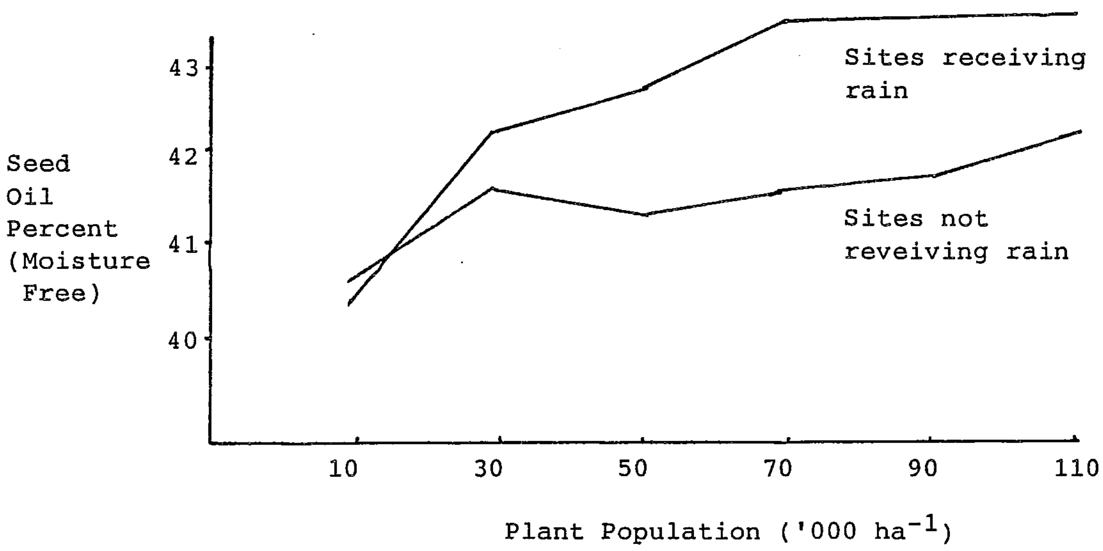


FIGURE 3. Effect of Plant Population on Oil Percentage of sunflower Seed in 1980 trials in Central Queensland.



(b) Effect of Row Spacing and Uniformity of Plant Distribution within Rows

Radford (Anon, 1978) found that row spacings of 36cm outyielded row spacings of 108 cm in most cases, and that the optimum row spacing for raingrown sunflower on the Darling Downs was 36 cm. Under Central Highlands conditions Radford (pers. comm.) suggested that row spacings up to 90 cm were unlikely to cause significant yield loss.

Robinson et al (1982) found in U.S. work that yield reduction from uneven plant distribution was 10% on average.

Radford considered that uniform plant distribution along the row was more important at low plant populations. Plants must be evenly distributed to fully exploit soil moisture, intercept maximum sunlight, and suppress weeds effectively. At higher plant populations, plants were closer together so uniform spacing was less critical.

These findings have major implications for the type of planter being used. Taylor (1978) found that a combine (which is not capable of uniform seed distribution) gave poorer yields than both a precision planter and uniformly hand-thinned plots.

Herbert (1974) found that at low seeding rates a conventional combine gave a less accurate seed drop than a plate planter, and consequently lower yield. At higher seeding rates this effect was less obvious and although the combine was still inferior to the plate planter in final yield, the difference was not significant.

C.P. Norris (pers. comm.) found in studies on the metering accuracy of various planting machines, that combines and machines with similar meters gave relatively poor uniformity of seed spacing in sunflower. Precision planters tended to give better uniformity of spacing although some types were no better than a combine. Further clarification of these differences is continuing.

However, several workers (Anon, 1978) concluded that although precision planting did tend to lead to better yields, quite acceptable uniformity of plant stand could be obtained from conventional planting equipment, with modifications and correcting setting-up.

2. EXTENSION INFORMATION

A brief resumé of extension recommendations used in Central Queensland, and observations and recordings made by extension workers are outlined below.

Cutler and O'Sullivan (O'Sullivan, 1976) collected the first detailed information on sunflower crops in the Central Highlands in a survey in 1972. They found that there was little yield gain by exceeding a plant population of 30,000 plants ha^{-1}.

McLaughlin (1978) pointed out in a review of sunflower problems on the Central Highlands that yields in 1977/78 were the best on record and plant populations averaged 15,000 - 20,000 plants ha^{-1}. This was despite recommendations of 25,000 - 37,500 plants ha^{-1}. G. Coles (Anon, 1978) commented that plant population counts on 46 crops in 1978 showed that the average was 16,000 plants ha^{-1}, ranging from 8,600 to 27,900 plants ha^{-1}. Yields were the best on record. No comments were made by either observer on likely yields from crops with higher plant populations.

Keefer (Anon, 1978) reasoned from existing research information that plant populations for the Central Highlands should be 25,000 - 35,000 plants ha^{-1}, but that commercial stands in the district were quite variable, from 8,000 to 30,000 plants ha^{-1}.

Hazard (1979) reported on an Agronomy Planning Meeting at Biloela Research Station at which sunflower plant populations were discussed at length. Discrepancies arose between research and extension recommendations, and farmer practice, as follows:

Research recommendation**			50,000	plants	ha^{-1}
Extension recommendation	25,000	-	40,000	"	"
Farmer practice*	30,000	-	40,000	"	"

(* Estimate only - survey needed to define established populations more clearly.

** From Radford's Darling Downs work only - there was a need for local data to be obtained, as well as a study of distribution within plant populations.)

Because of these discrepancies, extension staff in Central Queensland requested that further trial work be done to help resolve the problem. The work of Foreman (1981) already reported was then conducted, and was the first plant population study in sunflower in Central Queensland.

A knowledge of optimum plant populations is worthless unless farmers can achieve them. Spackman (in press) conducted a survey of crop establishment in 32 sunflower crops on the Central Highlands in 1980. The survey showed that in that particular year establishment was very poor, averaging 40%, and that the average plant population 20,300 plants ha^{-1}. The populations ranged from 2,500 to 48,500 plants ha^{-1}. 12.5% of crops fell into the "recommended" range of 30,000 - 40,000 plants ha^{-1}. Seventy-nine percent of growers aimed for a specific plant population, but only 18% achieved the target population. In 1972 O'Sullivan (1976) measured average emergence percentages of 50 - 55%.

Spackman found also that most farmers were not aware of plant populations achieved because they hadn't counted them, and were generally surprised at how low they actually were. Some farmers purposely aimed for relatively low populations.

Most machines used for planting sunflower (air-seeders, scariseeders, combines, etc), did not produce uniform plant stands. Use of equipment with better precision was not possible because of obstructions in cultivation. Some machines were set up to enable good stands to be achieved. Such equipment is still widely used. With increasing seed costs some farmers have tended to reduce seeding rates which could adversely affect the unformity of stand and the plant population achieved with such machines.

The latest plant population recommendations came from Radford (1981) who considered that dryland oilseed growers should aim at populations not lower than 35,000 plants ha^{-1}.

The work of Radford and Foreman generally agreed that plant populations of 30,000 to 50,000 plants per hectare were optimal for Central Queensland, depending on growing conditions. To further test these findings a trial was planted at Capella in 1981.

3. SUNFLOWER PLANT POPULATION TRIAL - CAPELLA, 1981

Aim:

To validate 1980 research findings on optimum plant populations for sunflowers on the Central Highlands in 1981.

Method

The trial was planted in conjunction with the varietal evaluation trial at Capella in mid-February, 1981.

Four-row (75cm row width) plots of two varieties - Hysun 11 (quick-maturing) and Hysun 31 (medium-slow maturing) were planted, on which six plant population treatments were imposed. Treatments were 10,000, 30,000, 50,000, 70,000, 90,000 and 110,000 plants ha^{-1}. Treatments were replicated twice. Other commitments prevented further replication.

Heads were harvested from the centre two rows of each plot and threshed in a stationary thresher.

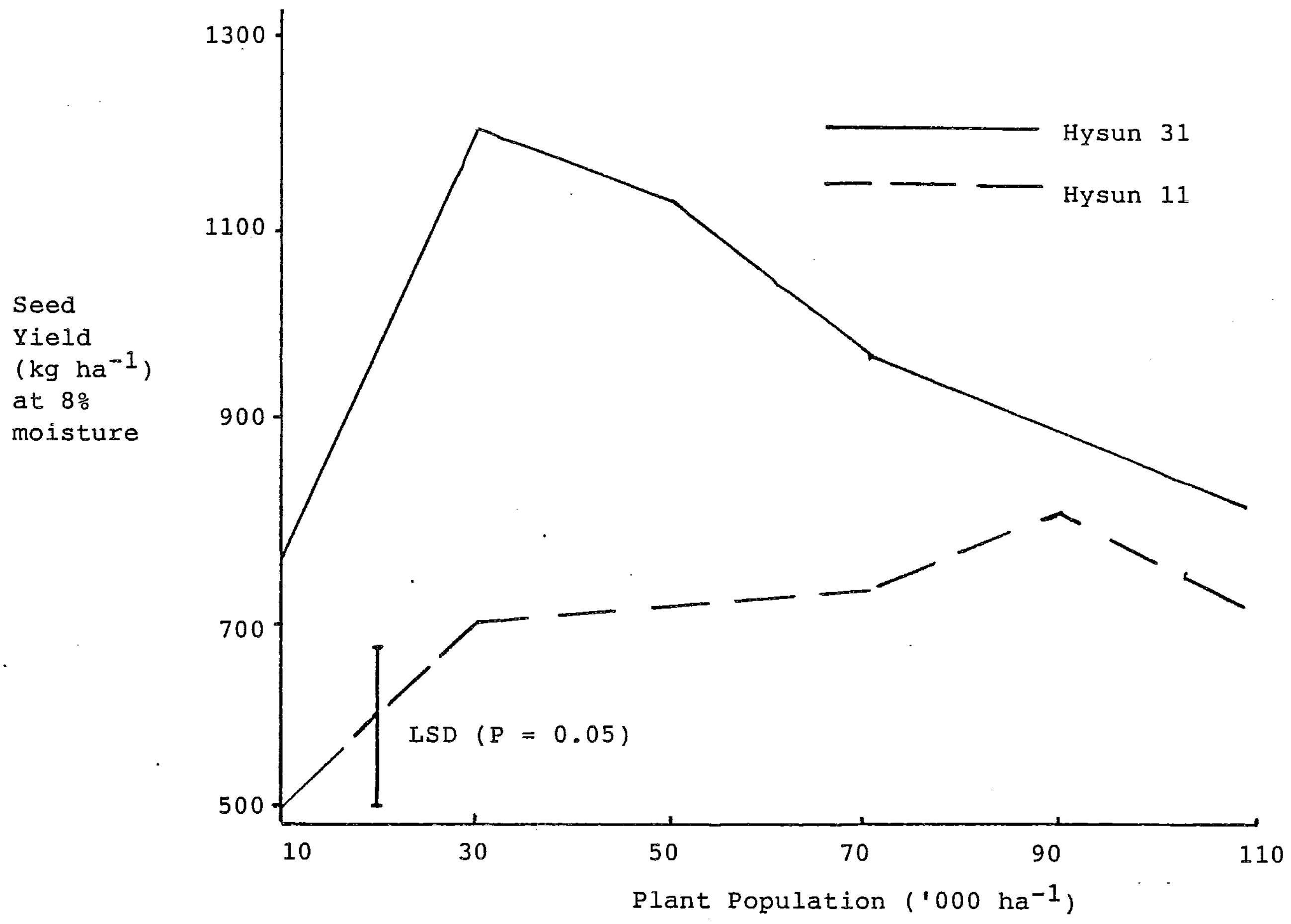
Seed yield, oil percentage, and oil yield data were collected.

Results

(a) Yield

The yield response of both varieties to plant population treatments is shown in Figure 4.

FIGURE 4. The Effect of Plant Population on Seed Yield of Two Sunflower Varieties at Capella in 1982.



Despite the apparently large differences in yield with changes in plant population in Hysun 31, there were no significant differences between treatments. This was probably due to high variability amongst treatment means (co-efficient of variation 16.3%) and insufficient replication.

In Hysun 11 the lowest plant population treatment (10,000 plants ha^{-1}) yielded significantly less ($P < 0.05$) than other treatments. There was no difference between treatments above 30,000 plants ha^{-1}.

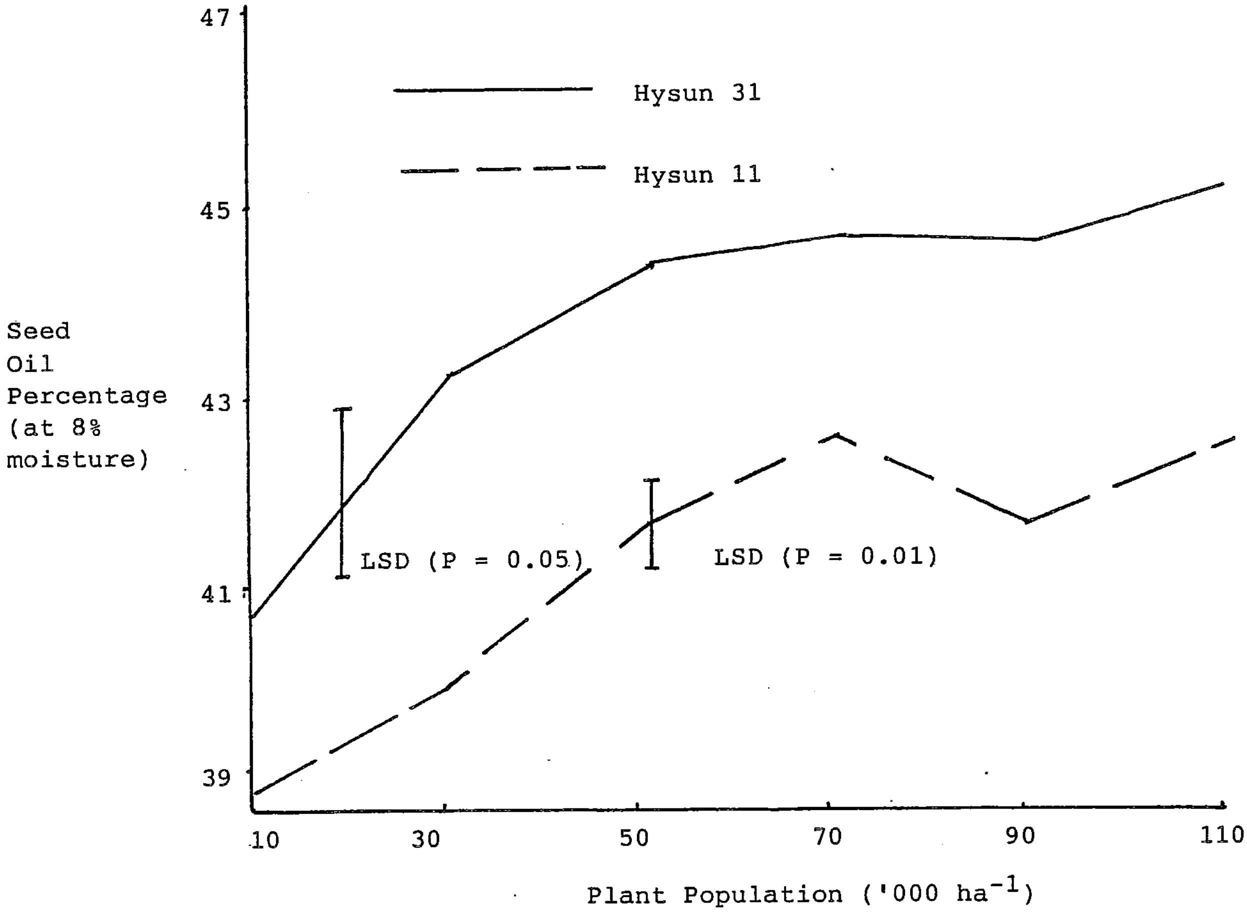
Peak yield in Hysun 31 occurred at 30,000 plants per hectare, and at 90,000 plants per hectare in Hysun 11. Although Hysun 31 was generally higher yielding than Hysun 11, the difference was not significant. Treatment means were 963,0 and 697.4 kg ha^{-1} respectively.

Yield data are shown in Appendix 1.

(b) Oil Percentage

Oil percentage increased with plant population in both varieties (See Figure 5.).

FIGURE 5. The Effects of Plant Population on Seed Oil Percentage of Two Sunflower Varieties at Capella in 1981.



In Hysun 31 the lowest plant population treatment was lower in oil percentage than all other treatments ($P < 0.01$). There was no difference between 30,000 and 50,000 plants ha^{-1}, and no difference between plant populations beyond 50,000 plants ha^{-1}, although oil percentages were highest from these treatments.

In Hysun 11 oil percentage increased with plant population ($P < 0.01$), with no significant increase beyond 70,000 plants ha^{-1}.

The oil percentage of Hysun 31 was most responsive to changes in plant population. Oil percentage was higher in Hysun 31 than Hysun 11, with treatment means of 44,0% and 41.5% respectively.

Oil percentage data are shown in Appendix 2.

(c) Oil Yield

Because of a lack of significant seed yield differences with plant population in Hysun 31, there were no differences in oil yield (kg ha^{-1}).

In Hysun 11 the lowest plant population had a significantly ($P < 0.05$) lower oil yield than all other treatments, with no difference in oil yield beyond 30,000 plants ha^{-1}.

Oil yield data are shown in Appendix 3.

Discussion

Plant populations below 30,000 plants ha^{-1} showed a yield disadvantage in this trial. Even though differences for Hysun 31 were not significant, the trend shown in Figure 1 would support this conclusion. The results support those of Foreman (1981) and Radford (1981). This trial does not clearly indicate an upper plant population limit for optimal yields, although there is a trend for Hysun 31 to produce lower yields at high, as well as at low plant populations.

Oil content tended to increase with plant popultion. As plant population increases, seed size usually decreases, with a corresponding reduction in hull percentage and increase in oil percentage. The results suggest that at least 30,000 plants ha^{-1} is optimal for oil percentage.

Oil yield is affected by plant population in a similar manner to seed yield. Oilseed sunflower performance should be judged on oil yield. Seed yield is typically more important in determining oil yield than seed oil percentage. Varietal evaluation work has also shown that seed yields has a dominant influence on oil yield, and is the most important criteria that the grower should use when selecting a variety (Spackman, 1979).

There is no conclusive evidence from this trial that the optimum plant populations for a quick-maturing variety should be higher than for a slow-maturing variety for a given yield level. However there was a trend for maximum yield to be reached at 30,000 plants per hectare for Hysun 31 and 90,000 plants per hectare for Hysun 11. It would be expected that because quick-maturing varieties produce less dry matter at flowering than a slower variety, they must have lower yield potential. A higher plant population may be needed to enable the quick-maturing crop to develop sufficient leaf area and dry matter for high yield potential, than is needed for a slower-maturing variety.

4. CONCLUSIONS

(a) Plant Populations

The trials conducted in 1980 and 1981 in Central Queensland suggest that plant populations in raingrown sunflower crops should not be less than 30,000 plants ha^{-1} for optimal yields over a range of growing conditions. This work closely agrees with Radford's suggestion of a lower limit of 35,000 ha^{-1}.

The plant population at the upper end of the optimum plant population range is less obvious from these trials. Foreman (1981) suggests that the optimal plant population at higher-yielding sites (1,000 kg ha^{-1}) is 50,000 plants ha^{-1}. Yield averages in the Central Highlands rarely reach 1,000 kg ha^{-1}, so 50,000 plants ha^{-1} is probably too high in most growing conditions. This may not be the case in other districts in Central Queensland.

Several factors need to be considered when deciding on an upper limit to the plant population range for a particular district. Under weed-free conditions where ample sub-soil moisture is available the yield goal is likely to be high, so the optimum plant population is likely to be high - perhaps 50,000 plants ha^{-1}. However if soil is relatively shallow, rainfall variability high, and heat-wave conditions more likely (such as in the Central Highlands), the optimal plant population is likely to be somewhat lower than 50,000 plants ha^{-1} because the yield goal is likely to be lower. In addition, with seed costs continually rising, growers prefer to aim for the lower end of the optimal plant population range in an effort to reduce planting costs.

The above argument suggests that plant populations should not be less than 30,000 plants ha^{-1} for optimal sunflower yields in Central Queensland. Where a high yield is likely (1,000 kg ha), plant population could be increased to 50,000 plants ha^{-1} without yield loss. Where the yield goal is lower, plant populations at the lower end of the range, such as 30,000 to 40,000 plants ha^{-1}, would be more suitable in most seasons.

(b) Plant Distribution

All the conclusions above are based on trials where highly-uniform plant stands were achieved by hand-thinning.

Such plant stands are impossible to achieve commercially in Central Queensland because of the relatively low establishment percentages. This is partly due to the planting machinery used and the rough seed-bed conditions in hastily-prepared or newly-developed cultivation.

Earlier discussion has suggested that where a uniformly-spaced plant population is not possible, the optimum plant population for yield under a particular set of conditions is likely to be higher than if a uniform plant population could be achieved. This supports the argument for higher plant populations. Machines in use on the Central Highlands generally do not give populations with uniform distribution, so higher plant populations are needed to compensate for lack of uniformity. A swing toward precision planters would be expensive and unlikely to occur because of the extensive nature of farming in the region.

5. IMPLICATIONS FOR EXTENSION

It would appear that there is now enough information to suggest that farmers should achieve a plant population of at least 30,000 plants ha^{-1} in Central Queensland. Farmers need to be made more aware of this, and must also become more aware of the plant populations they achieve and of losses occurring up to plant establishment.

It would appear that uniform plant populations out-yield non-uniform plant populations. Practices to improve planter performance need to be extended to farmers. Farm machinery extension personnel can assist in this regard.

6. IMPLICATIONS FOR RESEARCH

Trials conducted in Central Queensland have not adequately identified whether varieties in different maturity groups have differing optimum plant populations for yield. Sunflower is planted over quite a wide range of planting times in Central Queensland (late January to mid-March). As farmers learn to achieve plant populations of 30,000 plants ha^{-1} with adequate plant distribution, information on optimum plant populations for different maturity groups, at different planting times, will be needed to refine plant population recommendations.

It would appear that variation in plant distribution affects sunflower yields and that this effect may in turn be influenced by plant population. This interaction needs further research as it may have implications for plant population recommendations for different types of planters.

Methods of improving plant spacing with existing planting machinery needs further study. If yield is not reduced by wide rows, then wider rows could be used and the optimum plant population could be crowded closer within the row. This would allow better plant distribution within the row using conventional planting equipment.

7. ACKNOWLEDGEMENTS

The technical assistance of Mr. J. Ladewig in conducting the 1981 trial, and Mr. Darryl Nixon for assistance with hand-thinning, is appreciated.

Pacific Seeds, Emerald, donated seed for planting the trial.

Mr. Gary Blight, Biometry Branch, Rockhampton, carried out statistical analysis.

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APPENDIX 1

Effect of Plant Population on Seed Yield of Two Sunflower Varieties at Capella, 1981.

Plant Population '000/ha	Seed Yield (kg/ha)	
	Hysun 31	Hysun 11
10	749.43	501.90
30	1214.02	699.54
50	1136.24	716.7
70	967.54	731.78
90	893.44	816.04
110	817.23	718.26
MEAN	962.98	697.37
LSD (5%)	N.S.	145.74

APPENDIX 2

Effect of Plant Population on Seed Oil Percentage of Two Sunflower Varieties at Capella, 1981.

Plant Population ('000/ha)	Seed Oil Percentage	
	Hysun 31	Hysun 11
10	41.00	39.20
30	43.35	40.30
50	44.45	41.95
70	44.85	42.90
90	44.80	42.00
110	45.45	42.80
MEAN	43.98	41.53
LSD (5%)	1.15	0.946

APPENDIX 3

Effect of Plant Population on Oil Yield of Two Sunflower Varieties at Capella, 1981.

Plant Population '000/ha	Oil Yield (kg/ha)	
	Hysun 31	Hysun 11
10	307.27	196.78
30	527.53	281.91
50	505.17	301.02
70	434.12	313.97
90	400.40	342.74
110	371.68	307.39
MEAN	424.36	290.63
LSD (5%)	N.S.	62.73